Tuesday, April 24, 2018 8:45 AM

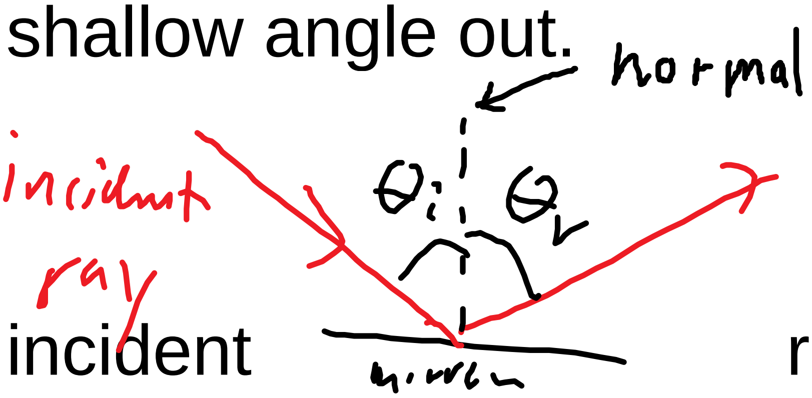
Reflection and Refraction

Demo - shine a laser have it hit

1. paper
2. mirror
3. plastic block

When it hits the paper, you see a dot on the paper but you don't see a reflecting dot

When it hits the mirror, you see the light reflect. If it is a shallow angle going in, it reflects at a shallow angle out.



incident ray reflected ray

normal is the line perpendicular to the surface of the mirror

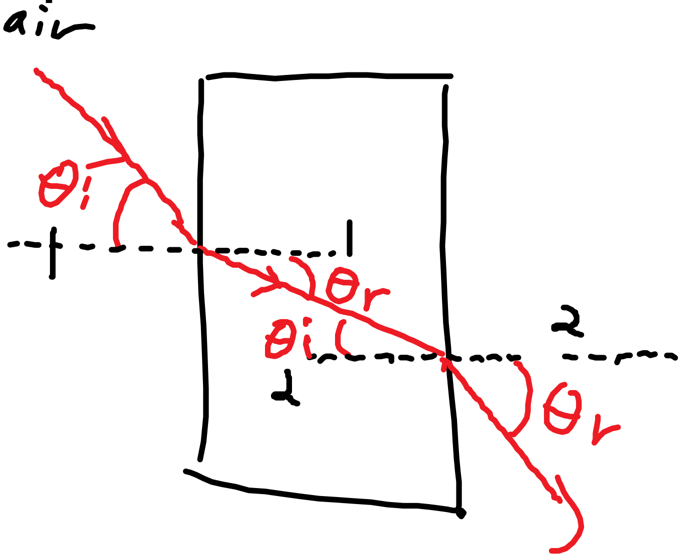
θ_i is the incident angle, from the incident ray to the normal

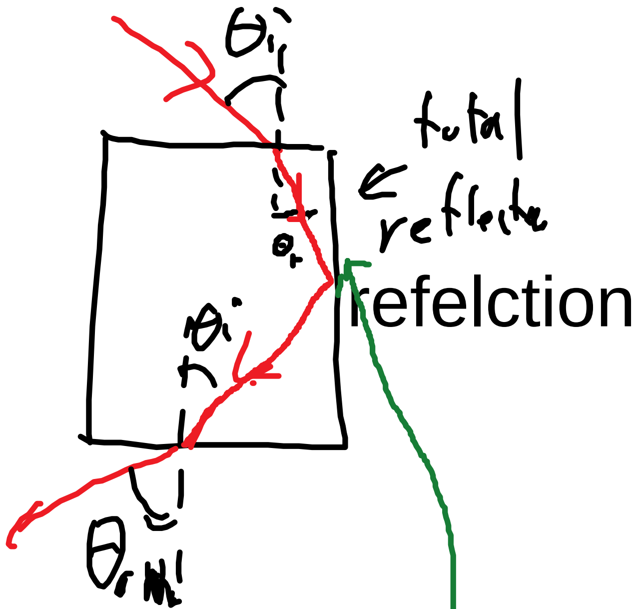
θ_r is the angle of reflection, the angle from the reflected ray to the normal

Law of Reflection

$$\theta_i = \theta_r$$

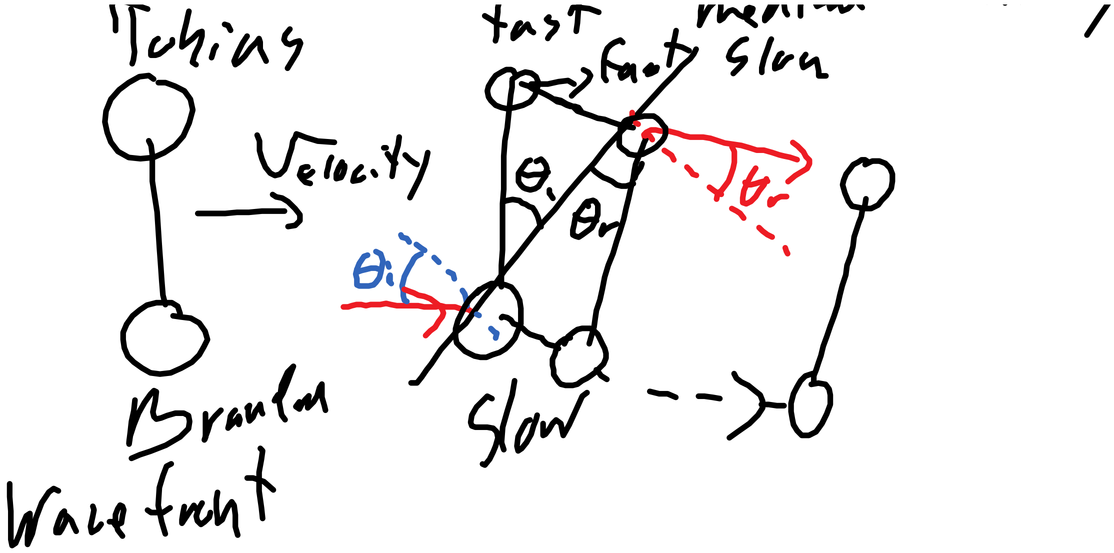
When you shine light through the plastic block, it changes direction.





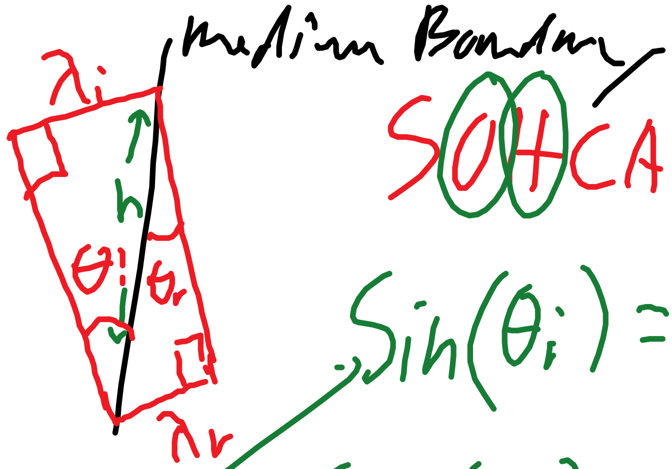
At each surface the light refracts, it changes direction. It doesn't refract if the angle of incidence is 0 and what's the deal with the total reflection?

Tobias and Brandon model a wavefront. When a wave goes from one medium to another, it changes speed. (speed is determined by the medium)



The wavefront changed direction because part of it (Brandon) went slower in the new medium.
Hey, let's derive our equation from that picture!

When you go from one medium to another, the speed changes, the frequency stays the same and the wavelength changes (proportionally to velocity).



SOHCAHTOA

$$\sin(\theta_i) = \frac{\lambda_i}{h}$$

$$\sin(\theta_r) = \frac{\lambda_r}{h}$$

$$n = \frac{\lambda_i}{\sin\theta_i} = \frac{\lambda_r}{\sin\theta_r}$$

$$v = \lambda f \qquad \lambda = \frac{v}{f}$$

$$\frac{v_i/f}{\sin\theta_i} = \frac{v_r/f}{\sin\theta_r}$$

$$\frac{v_i}{v_r} = \frac{\sin\theta_i}{\sin\theta_r}$$

Speed of light in a vacuum is c= 3.00x10^{8} m/s. To avoid using big numbers all the time, we invent a value called "the index of refraction, n"

define n = c/v

c is speed of light in a vacuum

v is the speed of light in the medium

values of n are determined experimentally- table on p 353 or google

air is essentially 1, 1.0003

glass has n = 1.5-1.6 depending on type
water has n=1.33 - lab in labbook p

Snell's law

$n_i \sin\theta_i = n_r \sin\theta_r$ $n=c/v$

In the lab you will shine light from air into a dish of water and light from the water into air.

predict using Snell's law the angle of refraction if the angle of incidence is 30.0º

a) air to water   b) from water to air

p354 Q1-4
pre-read the lab p45 and 46 (two labs in one)

a) incident medium is air, n=1.00
refracting medium is water, n=1.33
incident angle = 30.0º
refracting angle = ?

$n_i \sin\theta_i = n_r \sin\theta_r$

$1.00 x \text{Sin}(30) = 0.5 = 1.33 \text{Sin}\theta_r$

$\text{Sin}\theta_r = 0.5/1.33 = 0.3759$

θ_r = Asin or Sin^{-1} (0.3759) arcsine

usually inv button then sin button

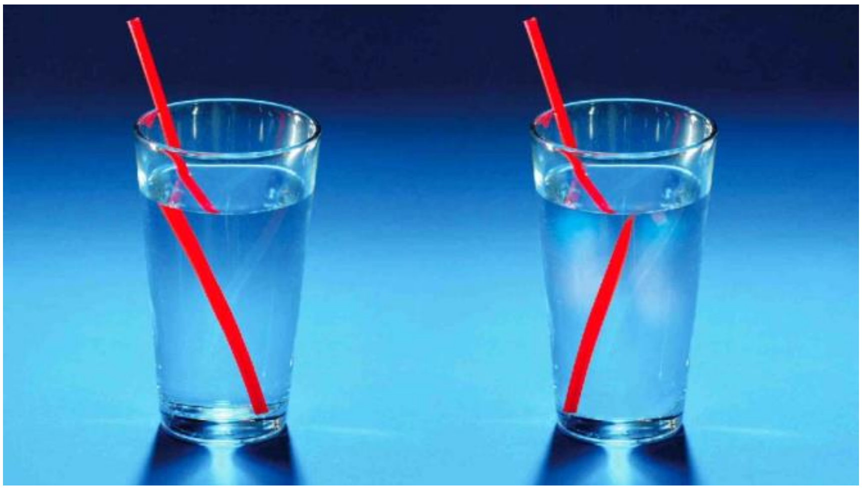
22.07994925450292

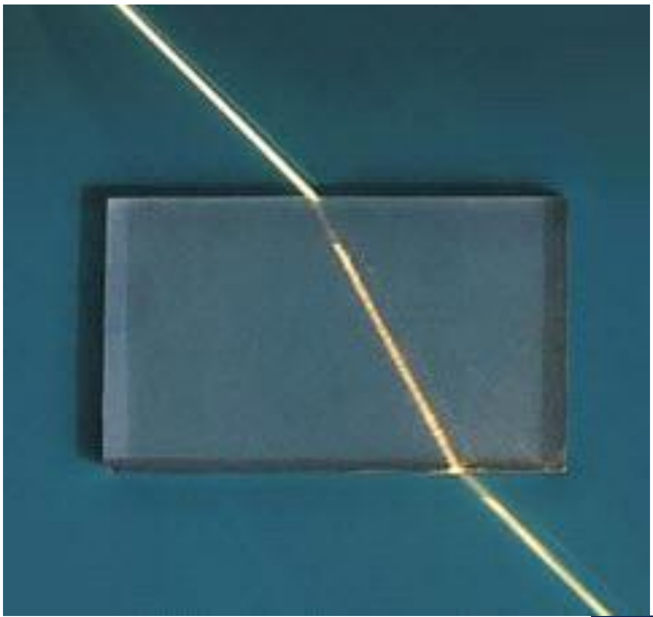
$\theta_r = 22.1^o$

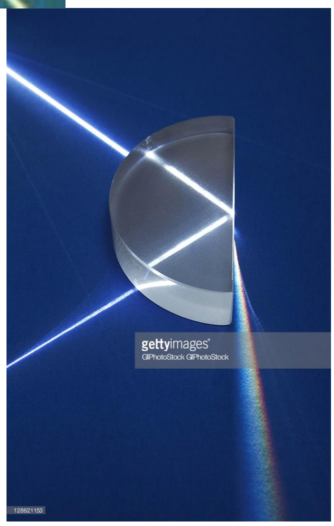
change calculators from rad to deg

Block 2-3

Reflection and Refraction

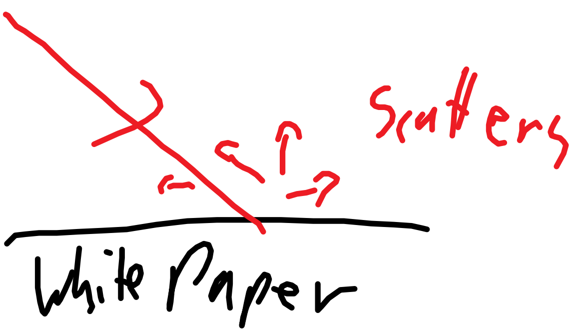


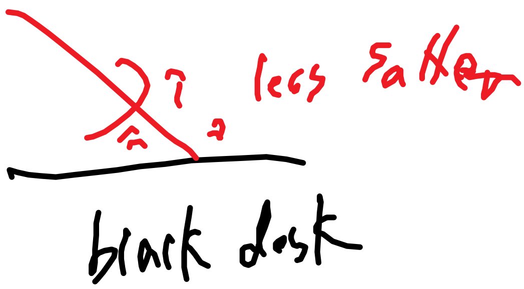




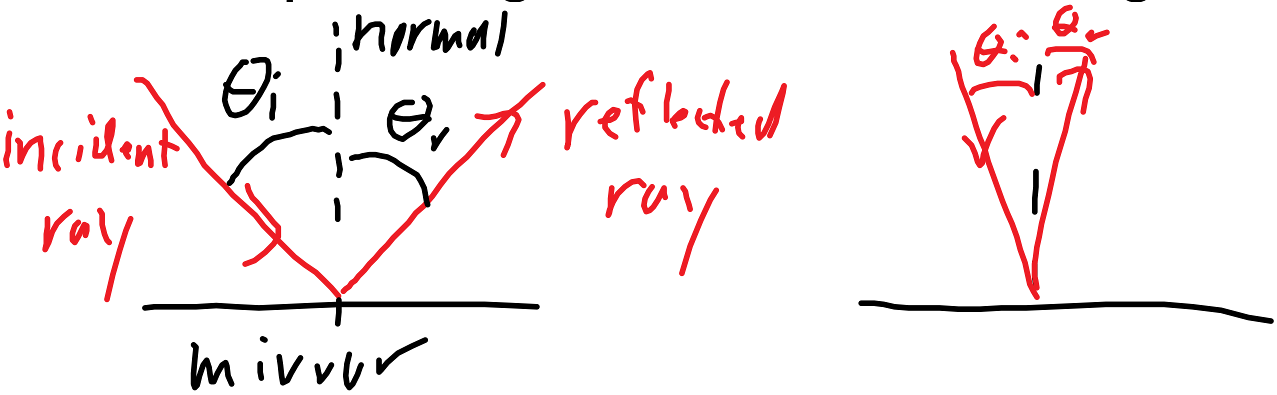
demo - laser hits paper, mirror and solid plastic block.

When the light hit the paper, you see a spot and a glow around but not perfect reflection.





When the laser hit the mirror, you see a reflected dot on the ceiling or the wall, depending on the incident angle.



normal is the line perpendicular to the surface. We measure angles relative to the normal.

θ_i is the incident angle, the angle from the normal to the incident ray.

(θ is the greek letter theta, for angles)

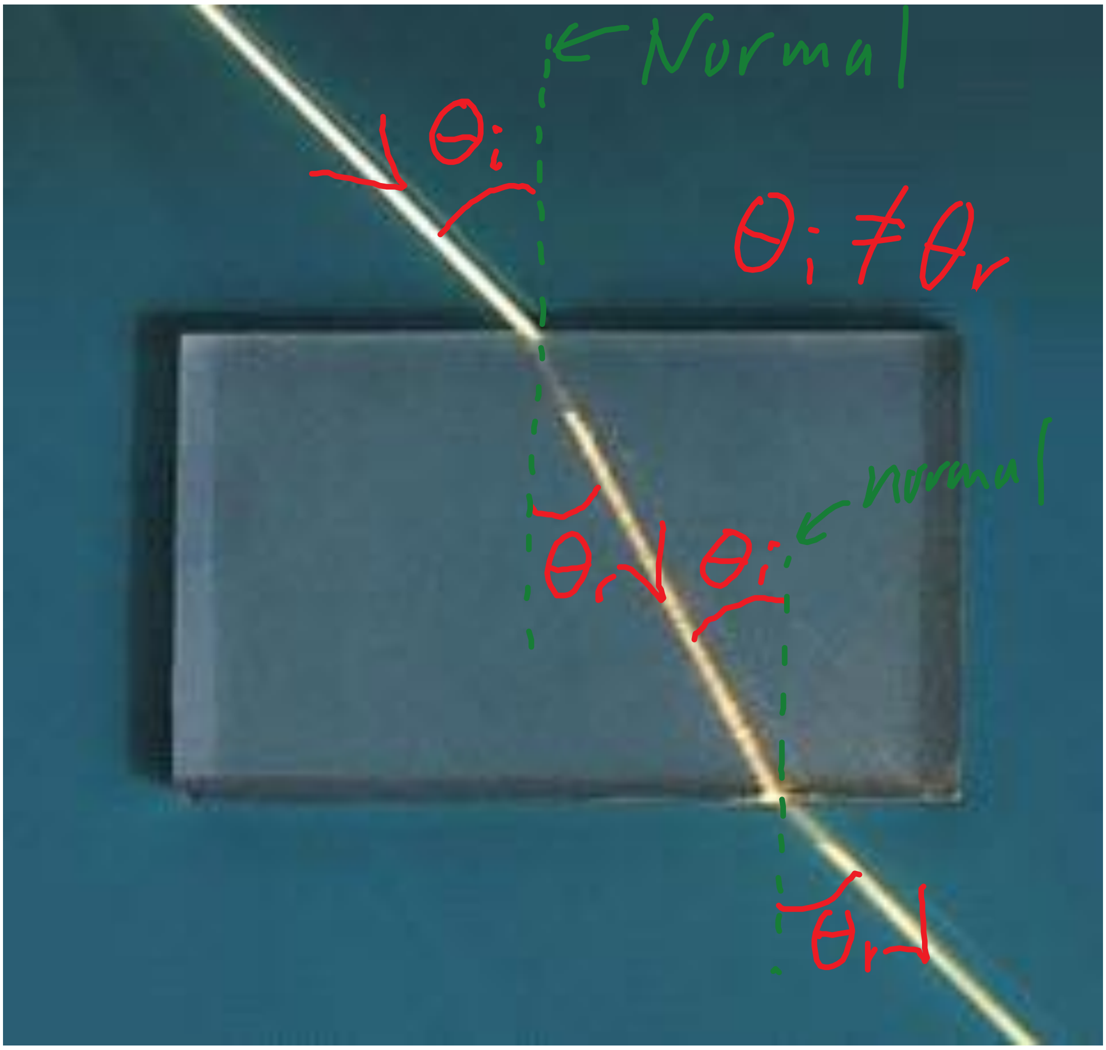
θ_r is the reflected or refracted angle, the angle from the normal to the reflected or refracted ray.

Law of Reflection:

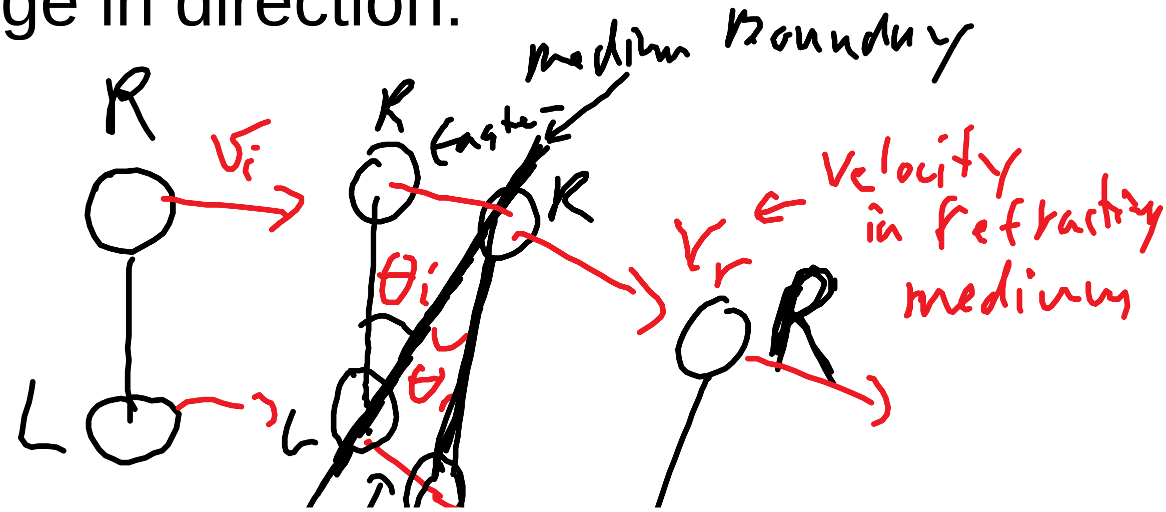
$\theta_i = \theta_r$

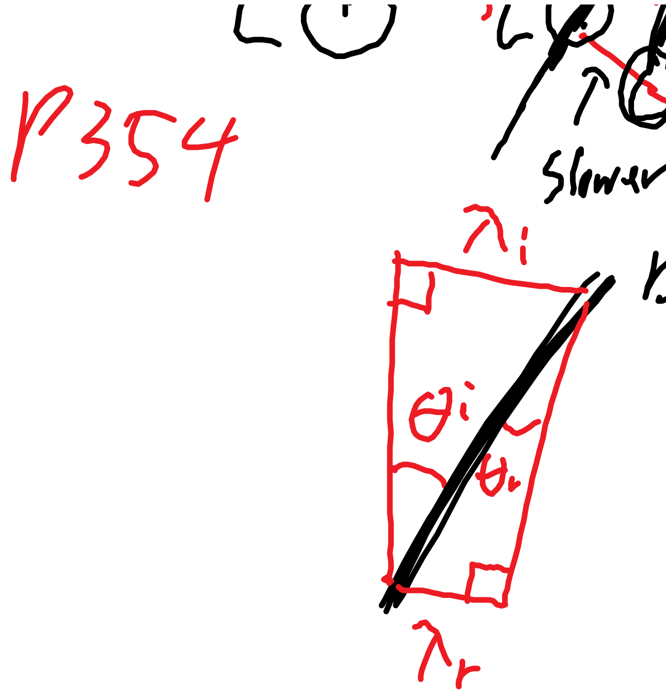
Demo - when light went through the plastic block, it mostly changed direction. This changing direction is called refraction.

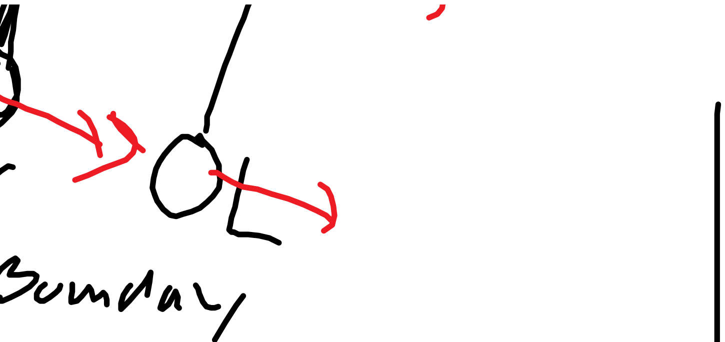
called refraction.



Demo:
Robert and Luna model a wavefront. When they hit a new medium they speed up or slow down. This causes a change in direction:







SOHCAHTOA
share hypotenuse
λ is opposite side
Sine = opp/hyp

when waves go from one medium to another, the waves change speed but the frequency is unchanged, so the wavelength changes.

$\sin\theta = \lambda/h \quad h = \lambda/\sin\theta$

$\lambda_i / \sin\theta_i = \lambda_r / \sin\theta_r$
$v = \lambda f$ so $\lambda = v/f$
$v_{i/f} / \sin\theta_i = v_{r/f} / \sin\theta_r$
since f is the same
$v_i/\sin\theta_i = v_r/\sin\theta_r$
$v_i/v_r = \sin\theta_i/\sin\theta_r$

speed of light, $c = 3.00\times10^8$ m/s
to avoid using big numbers we define a term, n is the index of refraction

term, n is the index of refraction
n=c/v v is the speed in the medium
sub in and you get Snell's Law:

$n_i \mathrm{Sin}\theta_i = n_r \mathrm{Sin}\theta_r$ $n=c/v$

Values for n are found experimentally and shown in a table on p 353.

n air = 1.0003

n water = 1.33

n glass is around 1.5

eg. In the lab next class you will shine light from air into water and water into air at various angles. Predict the angle of refraction if the angle of incidence is 30.0º and the light goes from

a) air to water   b) water to air

p354 Q1-4

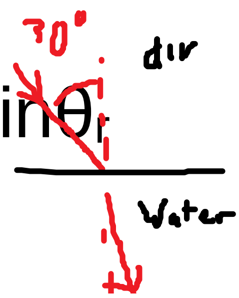
change calculator setting to degrees

pre-read p45 and 46 in labbook

a) $n_i \mathrm{Sin}\theta_i = n_r \mathrm{Sin}\theta_r$

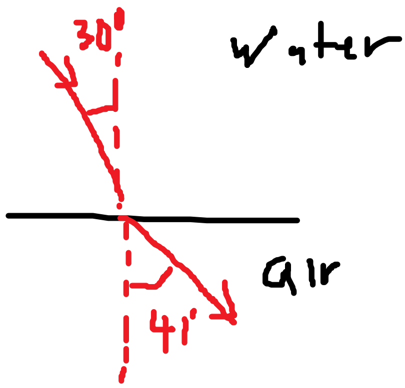
$1.0003 \times \mathrm{Sin}(30) = 0.50015 = 1.33 \mathrm{Sin}\theta_r$

$\theta_r = \mathrm{Sin}^{-1}$ or Asin(0.50015/1.33)= 22.08938684250247

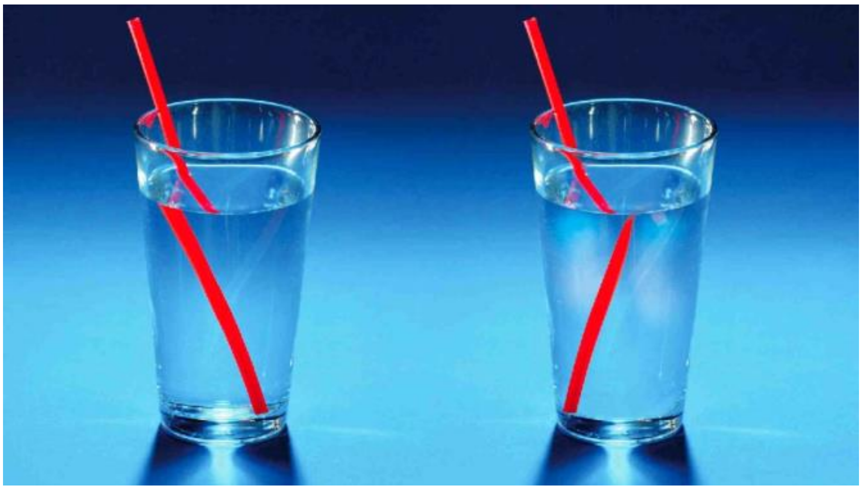


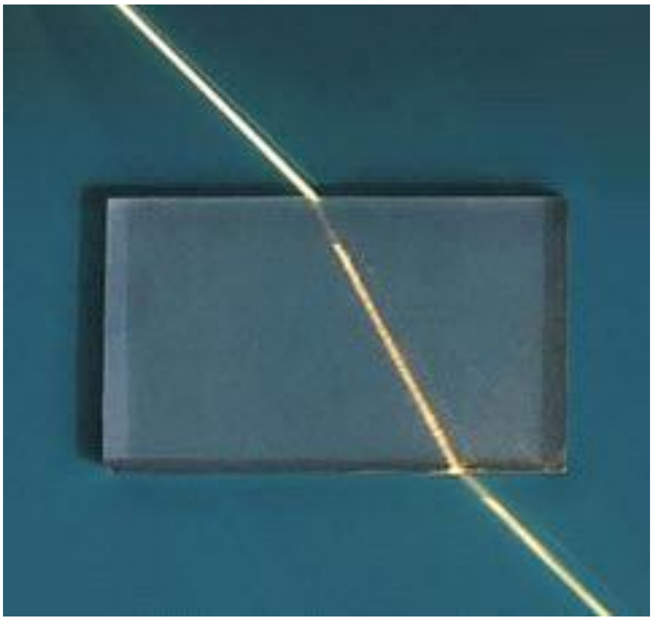
θ_r = Sin^{-1} or Asin(0.50015/1.33)=
22.08938684250247
22.08241319447225
22.1º

b) 1.33xSin(30)=0.665 = 1.00Sinθ_r
θ_r **=** Sin^{-1} or Asin(0.665/1.00)=
41.68232539333952
42º



Block 2-2
Reflection and Refraction

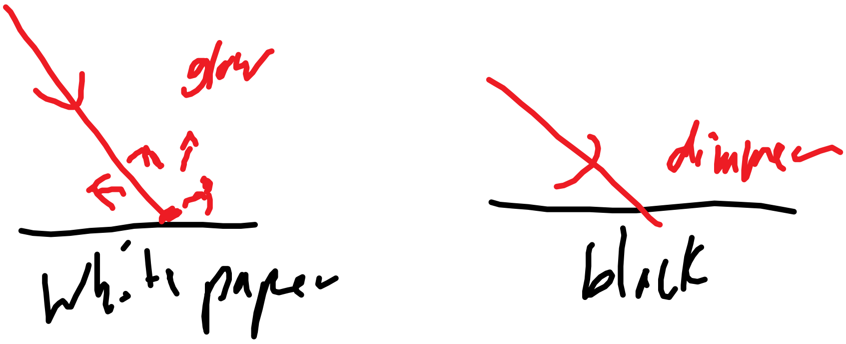




demo - laser hits paper, mirror and solid plastic block.

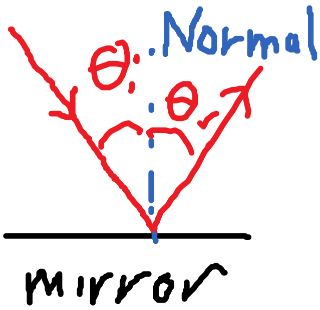
When the light hit the white paper, you see a red dot and a glow around the dot. If it hits something black, it is

dimmer.



When the light hit the mirror, it reflected. If the incident beam is steep, the reflected beam was also steep.

Law of Reflection:



$$\theta_i = \theta_r$$

The beam of light going into the mirror is the incident beam.

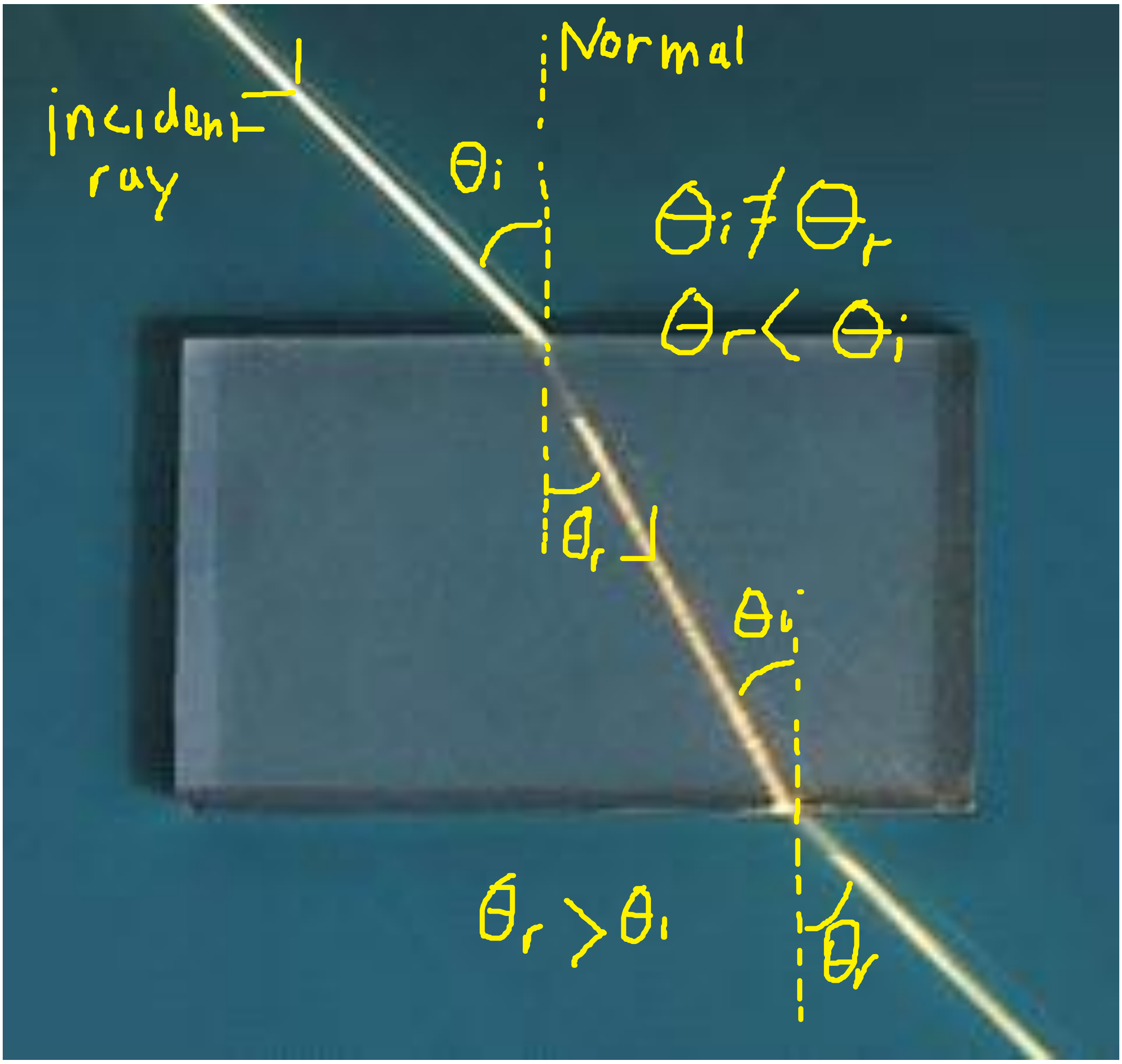
θ_i (theta) is the angle between the incident beam and the normal.

Normal is the line perpendicular to the surface.

θ_r (theta) is the angle between the reflected or refracted beam and the normal.

When light hit the plastic block, it

changed direction.

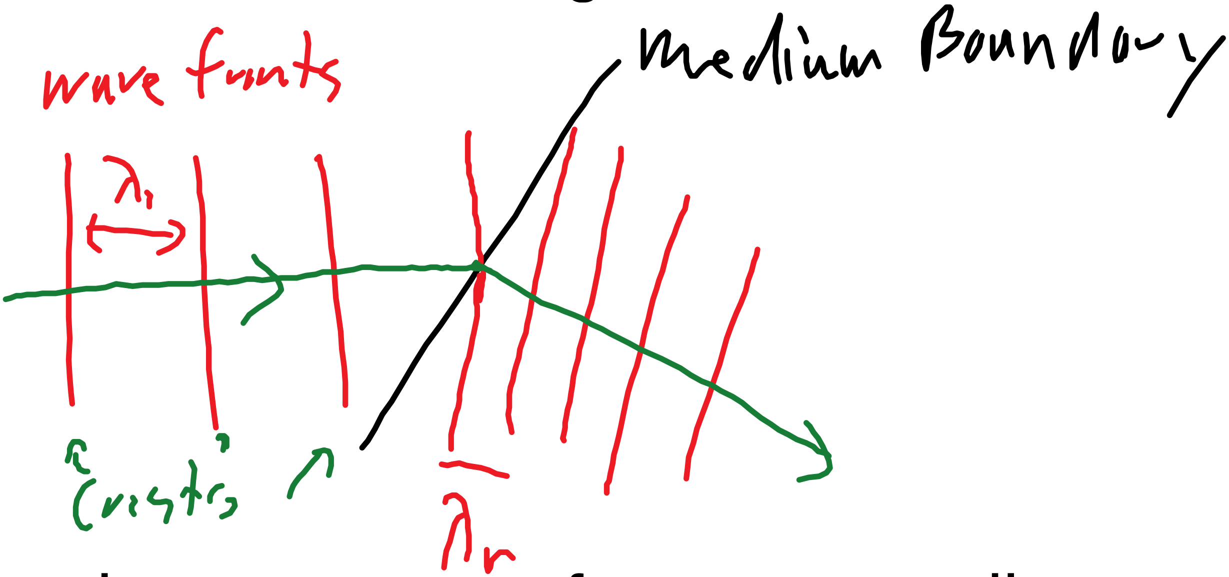


When the light entered the plastic block, the ray refracted towards the normal, and refracted away from the normal as it left.

Why?

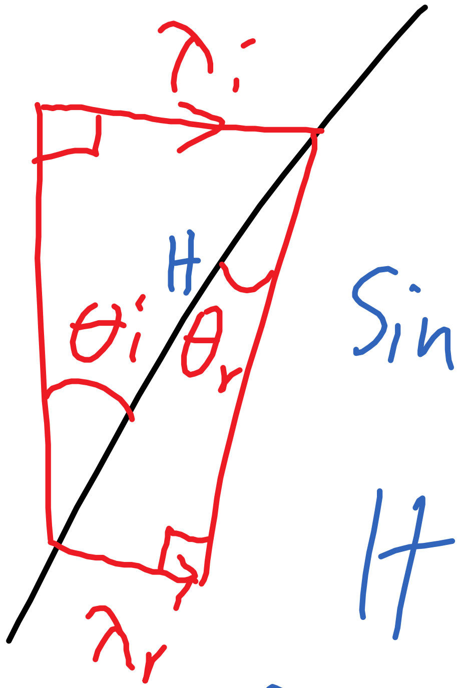
When waves go from one medium to

another the wavespeed changes. This causes the change in direction.



when you move from one medium to another the speed changes but the frequency doesn't change. Since v=λf, λ must also change.

Look at the medium boundary:



SOHCAHTOA

$$\sin\theta = \frac{\lambda}{H}$$

$$H = \frac{\lambda}{\sin\theta}$$

$$\frac{\lambda_i}{\sin\theta_i} = \frac{\lambda_r}{\sin\theta_r} \qquad \lambda = \frac{v}{f}$$

$$\frac{V_i/f}{\sin\theta_i} = \frac{V_r/f}{\sin\theta_r}$$

$$\frac{V_i}{V_r} = \frac{\sin\theta_i}{\sin\theta_r}$$

the speed of light in a vacuum is 3.00×10^8 m/s
to avoid big number all the time, we use a quantity called the index of refraction, n

$n=c/v$

v is the speed of light in the medium

by subbing into the above equation you end up with Snell's Law:

$n_i \sin\theta_i = n_r \sin\theta_r$ $n=c/v$

n values are determined

experimentally and found in a table p353 in textbook (or google)

vacuum n = exactly 1

air n = 1.0003   (no units)

water n=1.33

glass n is about 1.5

eg. In the lab next class, you will shine light through water. If the angle of incidence is 30.0º, what will be the angle of refraction for

a) light going from air into water?

b) light going from water to air?

p354 Q1-4

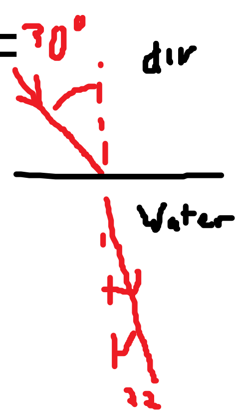
pre-read the lab p45-46

air   water

a) $n_i \mathrm{Sin}\theta_i = n_r \mathrm{Sin}\theta_r$

1.0003xSin(30)=0.50015 = $1.33\mathrm{Sin}\theta_r$

θ_r = Sin^{-1} or Asin(0.50015/1.33)=



22.08938684250247

22.08241319447225

22.1º

b) 1.33xSin(30)=0.665   = $1.00\mathrm{Sin}\theta_r$

θ_r **=** Sin^{-1} or Asin(0.665/1.00)= 41.68232539333952

41.7º